PhD in Electrical, Electronics and Communications Engineering

Research Title: Compact modeling of complex and multiphysics dynamical systems

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Context of the research activity	The main application area for this research project is model-based Computer-Aided Design (CAD) for multiphysics systems. The design and qualification of such complex systems is nowadays heavily based on numerical simulations, which are often based on first-principle field formulations. However, fully automated system optimization and design centering based on repeated simulations is still unfeasible due to overwhelming complexity. Model Order Reduction (MOR) approaches aim at reducing this complexity by replacing complex systems by compact dynamical models, whose responses match up to a user-defined accuracy those of the original system. Although MOR is now well-established, almost no results are available for robust generation of compact surrogate dynamical models embedding several design parameters (geometry, sizes, materials) from system response data. This research project wants to fill this gap, by producing a set of reliable algorithms for parameterized model extraction. Since the approach is methodological, the possible application areas are expected to cover any multidisciplinary engineering field that may benefit from the availability of systematic methods that, learning from massive amounts of system response data, extract low-complexity, robust, and parameterized models for system-level design and optimization.

Objectives	This research activity aims at developing novel algorithms for the automated generation of compact (reduced-order) models of complex dynamical (possibly multiphysics) systems. The demand for such compact (simple yet accurate) models is dramatically increasing in several cross-disciplinary application areas, due to the requirement of performing fast numerical simulations during design flows in practically all fields of engineering. Both data-driven (starting from measurements) and projection/truncation-based (starting from first-principle or field formulations) approaches will be considered for model extraction. Also, various multidisciplinary application areas will be covered,

	including electronics and telecommunications, energy, thermal, mechanical, acoustic and coupled multiphysics problems. Specific modeling tasks will be developed in collaboration with prominent companies that are active in the respective application fields. Specific emphasis will be on systems whose response depends on external parameters (geometrical, material, ambient, bias conditions,…), whose explicit dependence must be included in some approximate closed-form in the models. This parameterization in turns enables design and optimization flows based entirely on the compact models, leading to robust and reliable designs. The main challenge in this parameterized modeling setting is the possibly high-dimensional nature of the parameter space, which will require specialized techniques for data and model compression, including high-order tensor description, storage, handling, complemented by low-rank and hierarchical approximations, thus drawing ideas from and providing contributions to the broad field of “big data”.

Skills and competencies for the development of the activity	A solid background in electrical/electronic engineering; well-developed skill in both analytical and numerical math; proficiency in Matlab/Octave or other high-level scientific software. Experience in model order reduction and model identification is welcome.